

MMIC Power Amplifier Chip Set Developed for 70-115 GHz

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The development of high frequency MMIC power amplifiers has many applications to astrophysics and space science. In particular, high frequency power amplifiers can be used as drivers for local oscillator sources at frequencies into the THz range. These local oscillators can be used in receiver systems to study such phenomena as the early universe, galactic evolution, and stellar life cycles, to name a few of the possible applications. Commercial applications include automotive radar systems and telecommunications.

This paper presents the results of a collaboration of work to develop wide-band power amplifiers above 100 mW which cover most of W-band (70-110 GHz). Designs were performed at the Jet Propulsion Laboratory, TRW, and the University of Massachusetts. MMIC amplifiers were fabricated by TRW using a 0.1 μm 2 mil GaAs pseudomorphic HEMT process, already demonstrated at 94 GHz to provide high power amplifiers [1].

We performed on-wafer vector network analyzer testing of the MMICs using frequency extension modules to cover the range 65-115 GHz[2], and tested the chips for bandwidth and gain. Figure 1 shows small signal data on several of the amplifiers. Four types of output stage gate peripheries were used to facilitate driver chips and high power chips, and consisted of designs with 160 μm , 320 μm , 640 μm (driver designs) and 1.28 mm (power design) gate peripheries. The chips were then diced, and packaged in single chip modules designed for the WR10 waveguide band. Each module consisted of a waveguide transition [3], with off-chip capacitors inserted in DC bias lines for low frequency stability. The module design allowed for convenient cascading of modules to achieve high power.

We performed large signal power measurements on the MMIC modules using a tunable source at the input (either a YIG-based multiplier chain or a Backward Wave Oscillator (BWO)), to drive the modules. A calibrated power meter with W-band sensor attachment was used to measure the output power.

The YIG oscillator was used to drive two driver amplifier modules cascaded with a power amp module. We were able to obtain a record power-bandwidth for this frequency of >100 mW from 90-101 GHz for this system. Figure 2 shows the data, as well as a photograph of the modules. Similar measurements were performed with a BWO as the driving power source to cover frequencies outside the YIG bandwidth. The results for a 72-81 GHz driver + power amp and a 100-114 GHz driver + power amp are shown in Figure 3.

Additional results will be presented, and measurement methods will be discussed.

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[1] P. Huang *et al*, "A 94 GHz 0.35-W Power Amplifier Module," IEEE Trans. Microwave Theory and Tech, 45(12) p.2418.

[2] T. Gaier, L. Samoska, C. Oleson, G. Boll, "On-Wafer Testing of Circuits through 220 GHz," presented at the Ultrafast Electronics Conference, April 1999.

[3] Y. C. Leong, S. Weinreb, "Full Band Waveguide-to-microstrip Probe Transitions," 1999 IEEE MTT-S Digest, Anaheim, CA, vol.4, p 1435.

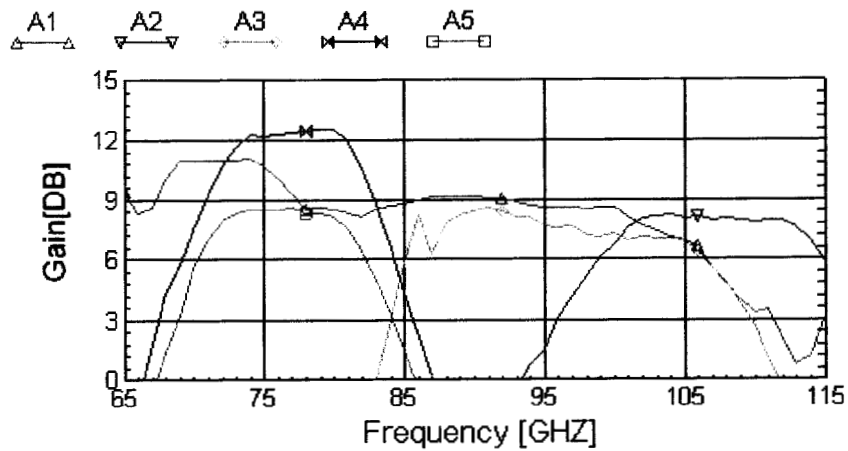


Figure 1. Small signal data from five different W-band MMIC amplifiers.

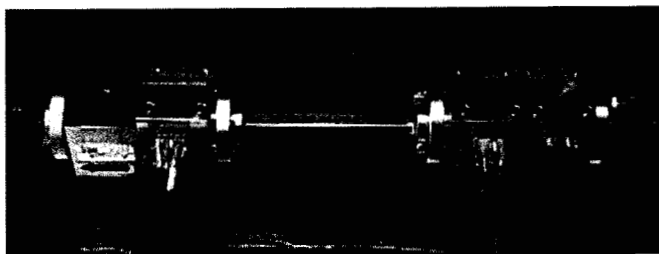
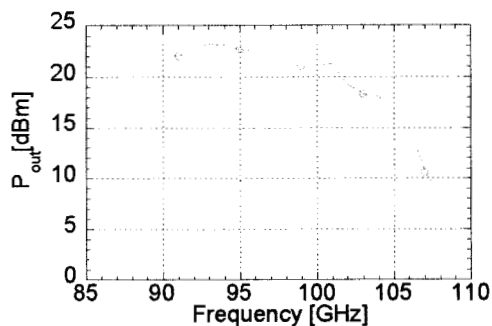


Figure 2. Output power as a function of frequency as obtained from 2 driver amp modules + 1 power amp module, shown in the above photograph.

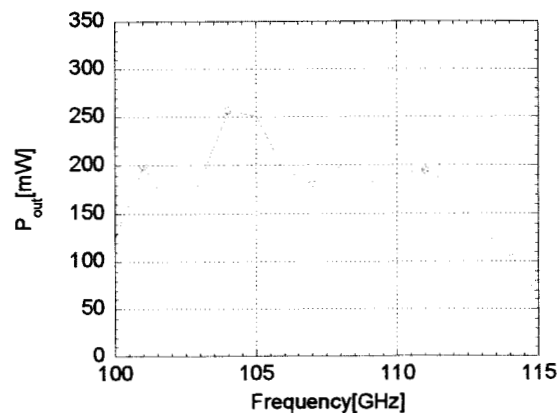
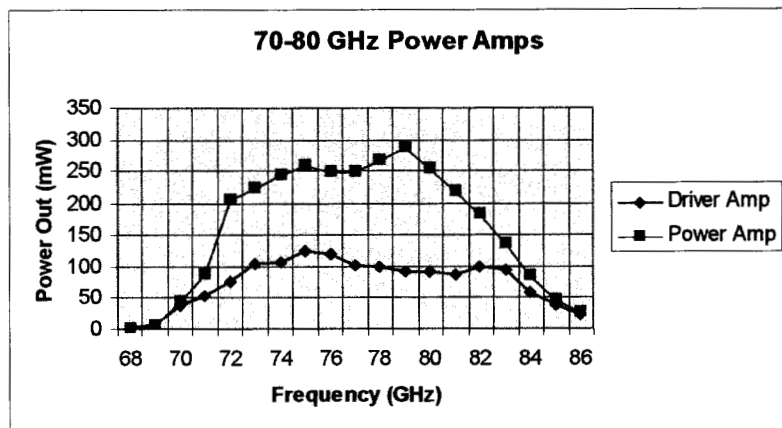


Figure 3. Output power obtained from a) a cascade of 71-82 GHz driver amp + power amp, b) a cascade of 100-114 GHz driver amp + power amp.